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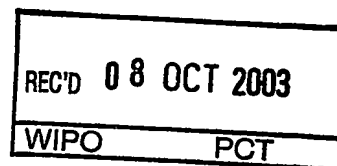
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## CERTIFICATE



This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 21 January 2003 with an application for Letters Patent number 523733 made by KENNETH WILLIAM PATTERSON DRYSDALE.

Dated 16 September 2003.

Neville Harris  
Commissioner of Patents, Trade Marks and  
Designs



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Patents Form No. 4

Our Ref: RC503733

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PROVISIONAL SPECIFICATION

A TURBINE AND A NOZZLE FOR A TURBINE

I, **KENNETH WILLIAM PATTERSON DRYSDALE**, a citizen of Australia, of  
8A Elm Avenue, Belrose, New South Wales, Australia do hereby declare  
this invention to be described in the following statement:

PT0486234

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***A TURBINE AND A NOZZLE FOR A TURBINE*****TECHNICAL FIELD**

The present invention relates to an apparatus for energy generation or recovery. More particularly, but not exclusively, the present invention relates to a turbine structure which may be used with a refrigeration cycle and preferably for power generation from an air conditioning cycle.

The term "fluid" or "working fluid" is used throughout the specification to relate to any suitable fluid but preferably, unless the context indicates otherwise, to a gaseous or vaporised fluid.

**BACKGROUND ART**

In order to make refrigeration cycles as efficient as possible a turbine may be added to the cycle to recover a portion of the energy otherwise wasted to atmosphere. Previous turbines have not been optimised for such a use and may not provide the maximum possible power output.

**OBJECT OF THE INVENTION**

It is an object of a preferred embodiment of the invention to provide a turbine and/or a nozzle for a turbine and/or a method of converting energy from a fluid stream to rotational energy and/or a method of communicating a working fluid to a turbine which will overcome or ameliorate problems with such apparatus and/or methods at present, or at least one which will provide the public with a useful choice.

Other objects of the present invention may become apparent from the following description, which is given by way of example only.

#### **SUMMARY OF THE INVENTION**

According to one aspect of the present invention, there is provided a turbine including a rotor chamber and a rotor rotatable about a central axis within said rotor chamber and including at least one exhaust aperture located centrally of said rotor and extending through said rotor generally in the direction of said central axis, the rotor further including a plurality of spaced apart, substantially spiral shaped channels, each spiral shaped channel having an inlet at substantially the outer periphery of said rotor and an outlet into said exhaust aperture, the cross-sectional area of each said spiral shaped channel continuously reducing between said inlet and said outlet apertures, the turbine further including at least one nozzle for communicating a fluid at a first pressure into the inlet of said spiral shaped channels and fluid receiving means operable at a second pressure lower than the first adapted to receive fluid from said at least one exhaust aperture, wherein, in use, the change of momentum of said fluid passing through said spiral shape channels imparts a turning force on said rotor.

Preferably said exhaust aperture may extend substantially parallel to said central axis.

Preferably said spiral shaped channels may be substantially circular in cross-section.

Preferably the cross-sectional area of the inlet to each said spiral shaped channel may be substantially six times the area of the corresponding outlet cross-sectional area.

Preferably the centreline of said spiral shaped aperture may intersect at least one line radial to said rotor at two points.

Preferably each said channel may include an expansion section upstream of said spiral shape section, the expansion section having a substantially continuously increasing cross section between an inlet of said expansion section at substantially the outer periphery of said rotor and said spiral shaped section, said expansion section adapted to cause a fluid travelling at substantially sonic or hypersonic velocity at the inlet of said expansion section to accelerate between said inlet and said spiral shaped section.

Preferably the centreline of said expansion section may be substantially straight.

Preferably the pressure difference between said first pressure and said second pressure may be sufficient to accelerate said fluid to a hypersonic speed between said nozzle and said exhaust aperture.

Preferably said fluid may accelerate to a hypersonic speed between said nozzle and said rotor.

According to a second aspect of the present invention there is provided a nozzle for a turbine, the nozzle including an inner chamber

which includes an inner chamber inlet adapted to receive a working fluid at a first temperature and density and an inner chamber outlet adapted to communicate a jet of said working fluid at a second temperature and density to said turbine, the nozzle further including an outer chamber substantially surrounding said inner chamber and adapted to receive a heating fluid through an outer chamber inlet and to exhaust said heating fluid through an outer chamber outlet, wherein in use, heat is transferred from said heating fluid to said working fluid in said inner chamber, thereby increasing the energy of said working fluid in said jet.

Preferably said inner chamber may decrease in cross-section between said inner chamber inlet and said inner chamber outlet.

Preferably the ratio of cross-sectional area of said inner chamber inlet to said inner chamber outlet may be selected to promote hypersonic flow at said inner chamber outlet.

Preferably the ratio of cross-sectional area of said inner chamber inlet to said inner chamber outlet may be at least 6:1.

Preferably said inner chamber may include a first subchamber in fluid communication with a downstream second subchamber of smaller cross-sectional area than said first subchamber.

Preferably said nozzle may be part of a fluid cycle and said heating fluid may be working fluid from a higher temperature part of said cycle than the working fluid entering said inner chamber inlet.

Preferably said heat transfer may be sufficient to heat said jet of working fluid at said inner chamber outlet to a superheated vapour state.

Preferably said outer chamber inlet may be proximate said inner chamber outlet and said outer chamber outlet may be proximate said inner inlet.

Preferably said nozzle may be adapted to accelerate said working fluid to at least a substantially sonic velocity at a point outside said nozzle.

According to a third aspect of the present invention, there is provided a method of extracting energy from a fluid stream, the method including providing a turbine including a rotor chamber and a rotor rotatable about a central axis within said rotor chamber and including at least one exhaust aperture located centrally of said rotor and extending through said rotor generally in the direction of said central axis, the rotor further including a plurality of spaced apart, substantially spiral shaped channels, each spiral shaped channel having an inlet at substantially the outer periphery of said rotor and an outlet into said exhaust aperture, the cross-sectional area of said spiral shaped channel continuously reducing between said inlet and said outlet, the method further including providing at least one nozzle for communicating said fluid at a first pressure into the inlet of said spiral shaped channels and fluid receiving means operable at a second pressure lower than the first adapted to receive said fluid from said at least one exhaust aperture, wherein, in use, the change of momentum of said fluid passing through said spiral shape channels imparts a turning force on said rotor thereby converting energy from said fluid stream into rotation of said rotor.

Preferably said exhaust aperture may extend substantially parallel to said central axis.

Preferably the method may include providing each said channel with an expansion section upstream of said spiral shape section, the expansion section having a substantially continuously increasing cross section between an inlet of said expansion section at substantially the outer periphery of said rotor and said spiral shaped section, said expansion section adapted to cause a fluid travelling at substantially sonic or hypersonic velocity at the inlet of said expansion section to accelerate between said inlet and said spiral shaped section.

Preferably the pressure difference between said first pressure and said second pressure may be sufficient to accelerate said fluid to a hypersonic speed between said nozzle and said exhaust aperture.

Preferably said fluid may accelerate to a hypersonic speed between said nozzle and said rotor.

According to a fourth aspect of the present invention there is provided a method of communicating a working fluid to a turbine, the method including providing a nozzle including an inner chamber which includes an inner chamber inlet adapted to receive said working fluid at a first temperature and density and an inner chamber outlet adapted to communicate a jet of said working fluid at a second temperature and density to said turbine, the nozzle further including an outer chamber substantially surrounding said inner chamber and adapted to receive a



heating fluid through an outer chamber inlet and to exhaust said heating fluid through an outer chamber outlet, the method further including supplying said working fluid to said inner chamber inlet and said heating fluid to said outer chamber inlet, thereby heating said working fluid with heat from said heating fluid in said outer chamber, and communicating a jet of said heated working fluid to said turbine.

Preferably said inner chamber may decrease in cross-section between said inner chamber inlet and said inner chamber outlet.

Preferably the ratio of cross-sectional area of said inner chamber inlet to said inner chamber outlet may be selected to promote hypersonic flow at said inner chamber outlet.

Preferably the ratio of cross-sectional area of said inner chamber inlet to said inner chamber outlet may be at least 6:1.

Preferably the method may include providing said inner chamber with a first sub-chamber in fluid communication with a downstream second sub-chamber of smaller cross-sectional area than the first.

Preferably the method may include providing said nozzle as part of a fluid cycle wherein said heating fluid is working fluid from a higher temperature part of said cycle than the working fluid entering said inner chamber inlet.

Preferably the method may include heating said working fluid in said jet at said inner chamber outlet to a superheated vapour state.

Preferably the method may include locating said outer chamber inlet substantially proximate said inner chamber outlet and said outer chamber outlet substantially proximate said inner chamber inlet.

Preferably the method may include accelerating said working fluid to at least a substantially sonic velocity between said nozzle and said turbine.

According to a still further aspect of the present invention, a turbine and or a nozzle for a turbine(as herein defined), and/or a method of extracting energy from a fluid stream and/or a method of communicating a working fluid to a turbine (as herein defined), is substantially as herein described, and/or with reference to the accompanying drawings.

Further aspects of the invention, which should be considered in all its novel aspects, will become apparent from the following description given by way of example of possible embodiments of the invention.

#### **BRIEF DESCRIPTION OF DRAWINGS**

FIGURE 1. Shows a side view of a turbine rotor according to one aspect of the present invention.

FIGURE 2. Shows a sectional view through arrows A-A of the turbine rotor of Figure 1.

- FIGURE 3. Shows (very diagrammatically) an enlarged view of one channel of the turbine rotor.
- FIGURE 4. Shows (very diagrammatically) an enlarged view of an alternative channel according to a second embodiment of the present invention.
- FIGURE 5. Shows (very diagrammatically) a sectional view through a central plane of a nozzle for a turbine according to a second aspect of the present invention.
- FIGURE 6. Shows (very diagrammatically) a sectional view through a central plane of an alternative embodiment of the turbine nozzle.
- FIGURE 7. Shows an exploded view of a turbine according to one embodiment of the present invention.

#### **BRIEF DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION**

Those skilled in the art will recognise that the turbine and nozzle described herein may have application to extraction of energy from any suitable gaseous fluid flow where a pressure differential exists. It is anticipated that the turbine will be most useful as part of a thermodynamic cycle and that it will receive a hypersonic gaseous fluid jet. However, alternative applications are also possible. The turbine is described herein

with particular reference to its use as an energy recovery device in a refrigeration cycle.

Referring first to Figures 1 and 2, a turbine rotor 1 according to one aspect of the present invention includes a plurality of substantially spiral shaped channels 2 leading to a central exhaust aperture 3. The central exhaust aperture 3 may be central of the rotor 1 and may extend substantially in the direction of the central axis of the rotor 1. The cross-sectional area of each channel 2 may continuously decrease between an inlet 4 and an outlet 5. Preferably the ratio of the area of the inlet 4 to the outlet 5 may be substantially 6:1 in order to promote hypersonic operation with the minimum restriction to the flow of the working fluid.

Referring next to Figure 3, the centreline 6 of each channel 2 may intersect a radius 7 of the rotor 1 on at least two points, 8, 9 between the inlet 4 and the outlet 5.

A fluid flow, represented by arrows F, may enter a channel 2 through an inlet 4. As the direction of the fluid F is changed within the channel 2 the change in momentum of the fluid F may result in a turning force on the rotor 1. Preferably the turning force may be transmitted to either a suitable electrical energy generator or any other suitable mechanism which may be powered by a rotating shaft. It is preferred that the fluid F execute as close as possible to a 180° change in direction within the channel 2 in order to maximise the change in momentum and therefore the energy imparted to the rotor 1.

Referring next to Figure 4, a turbine according to a second aspect of the present invention may include an expansion section 10 upstream of a working section 11 formed by the spiral shaped channels of the previous embodiment. The angle A of the walls 12 of the expansion section may diverge so that fluid entering the inlet 13 at or above substantially sonic speeds may be accelerated to hypersonic speeds in the expansion section 10 before being slowed in the working section 11. Preferably the angle of expansion A of the expansion section 12 may be between 50° and 60° in order to promote hypersonic flow. The working section 11 may generate a turning moment in the same manner as the first embodiment described above.

It will be apparent to those skilled in the art that including an expansion section in a turbine rotor may allow the working fluid to be accelerated to hypersonic speeds within the rotor, eliminating the need for an expansion section in the nozzle supplying said rotor with working fluid.

Referring next to Figure 5, a nozzle for use with a turbine is generally referenced by arrow 100. The nozzle 100 may include an inner chamber 15 with an inner chamber inlet 16 for receiving a working fluid and an inner chamber outlet 17 of substantially smaller cross-sectional area for communicating a jet of working fluid, represented by arrow W, to a turbine or similar device. The inner chamber 15 may be substantially surrounded by an annular outer chamber 18 having an outer chamber inlet 19 and an outer chamber outlet 20. The outer chamber 18 may be supplied with a heating fluid flow represented by arrows H, through inlet 19, the temperature of which flow may be sufficiently above the temperature of the working fluid W, to ensure that heat Q is transferred

through the walls 21 of the inner chamber 15 from the heating fluid H to the working fluid W, thereby increasing the internal energy of the working fluid W. Preferably the cross-sectional area of the inner chamber inlet 16 may be at least six times greater than the cross-sectional area of the inner chamber outlet 17 in order to promote hypersonic flow either at or just beyond the outlet 17 of the nozzle.

Preferably the temperature of the heating fluid H in the outer chamber 18 may be sufficient to keep the working fluid W in the inner chamber 15 in at least a saturated vapour state as it expands and accelerates through the inner chamber 15. In a particularly preferred embodiment the heating fluid H may heat the working fluid W sufficiently that the jet exiting the nozzle 100 comprises substantially superheated vapour.

Preferably the inner chamber inlet 16 may be proximate the outer chamber outlet 20 and the inner chamber outlet 17 may be proximate the outer chamber inlet 19. In this way the heating fluid H may flow in substantially the opposite direction to the working fluid W, thereby optimising the heat transfer between the heating fluid H and working fluid W.

Figure 6 shows a nozzle 200 according to another embodiment of the invention. The nozzle 200 may include a first sub-chamber 15a substantially adjacent a second sub-chamber 15b which has a smaller cross-sectional area. The sub-chambers 15a, 15b may be joined by a first tapering transition section 21. Both sub-chambers 15a, 15b may be

surrounded by an outer chamber 18 and a heating fluid H as in the nozzle 100 described above.

A working fluid W may enter the nozzle 200 at a first temperature, density and speed. The fluid W may pass through the first sub-chamber 15a receiving heat  $Q'$  through the walls 21a of the chamber from the heating fluid H. The working fluid W may then flow through the first transition section 21 where it may be accelerated. As the working fluid W flows through the second sub-chamber it may receive further heat  $Q''$  from the heating fluid H in the outer chamber 18. Finally the working fluid W may accelerate through a second tapering transition section 22 to form a jet at the outlet 23. Those skilled in the art will appreciate that some heat will also be transferred to the fluid W in the transition sections 21, 22.

Preferably the geometry of the second transition section 22 may be configured such that the jet of fluid W continues to accelerate, and its cross-sectional area decrease, outside the second transition section 22. In this way the nozzle may be designed to promote sonic flow at a point outside the nozzle 200, thereby allowing hypersonic flow to be generated while keeping the outlet 23 of the second transition section 22 as large as possible.

It will be appreciated by those skilled in the art that superheating the working fluid may allow the density of the fluid to be kept as low as possible, thereby allowing a larger nozzle outlet area for a given outlet velocity. This in turn may minimise the restriction caused by the nozzle to

the flow of the working fluid, which may be particularly important if the fluid is part of a refrigeration cycle.

Referring next to Figure 7, complementary apertures (not shown) are provided in the turbine housing 24 which align with the aperture 3 (not shown) in the turbine rotor 1 when the turbine rotor 1 is assembled into a rotor chamber 24a within the housing 24. The turbine rotor 1 may drive a shaft 25 from which power may be extracted. A nozzle 26, which may preferably be one of the nozzles 100, 200 of the present invention, may be provided in the housing 24 and may provide a stream of fluid, preferably refrigerant, to power the turbine 300. The fluid may exhaust from the turbine to a low pressure sink. In a preferred embodiment the turbine may be positioned between the evaporator and the accumulator of a refrigeration cycle (not shown). If an accumulator is not present or included within the compressor then the turbine may be positioned between the evaporator and the compressor suction inlet.

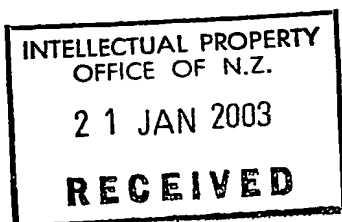
The extraction of power from a turbine shaft is well known to those skilled in the art and will not be described further.

Where in the foregoing description, reference has been made to specific components or integers of the invention having known equivalents, then such equivalents are herein incorporated as if individually set forth.

Although this invention has been described by way of example and with reference to possible embodiments thereof, it is to be understood that



modifications or improvements may be made thereto without departing from the spirit or scope of the invention.



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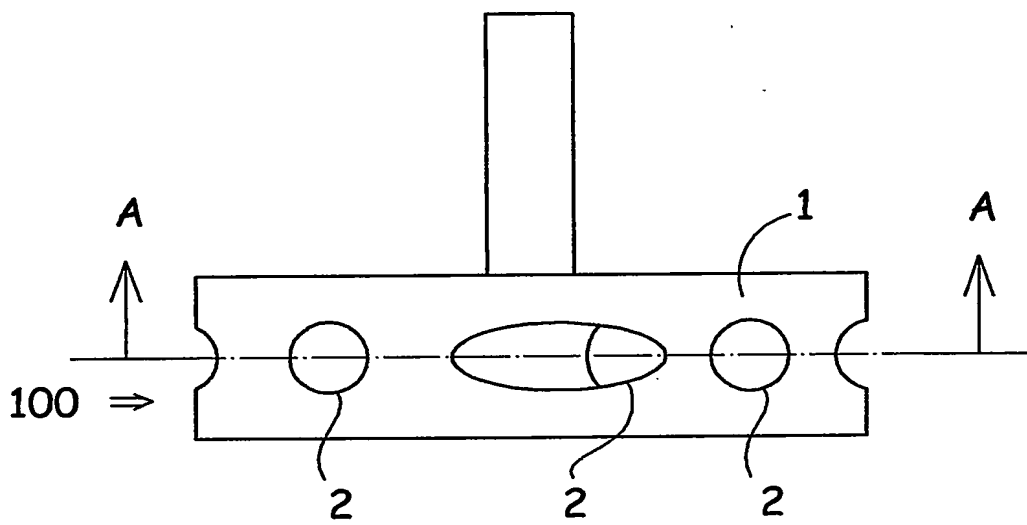


Fig 1

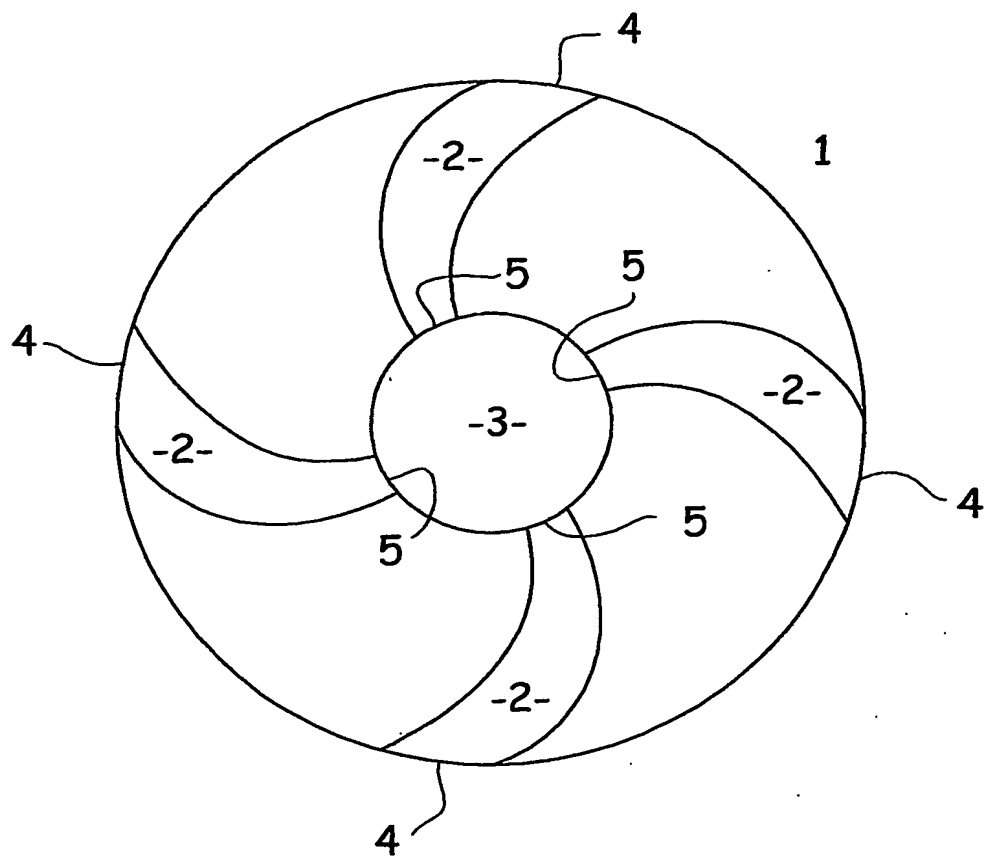


Fig 2

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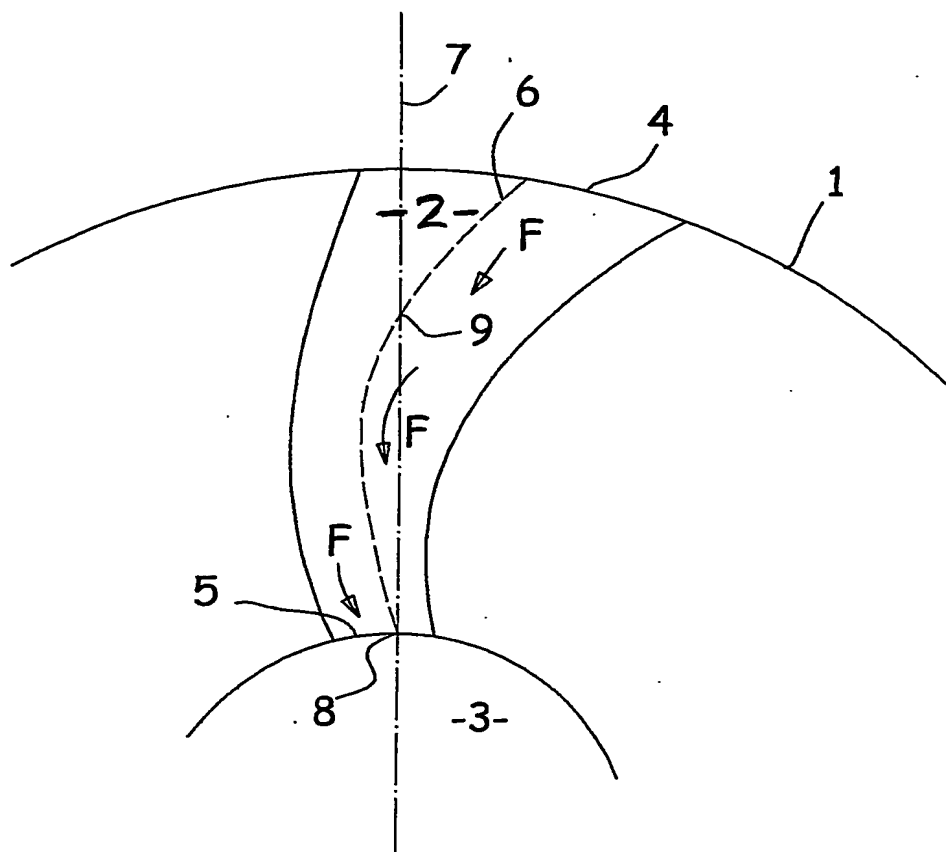


Fig 3

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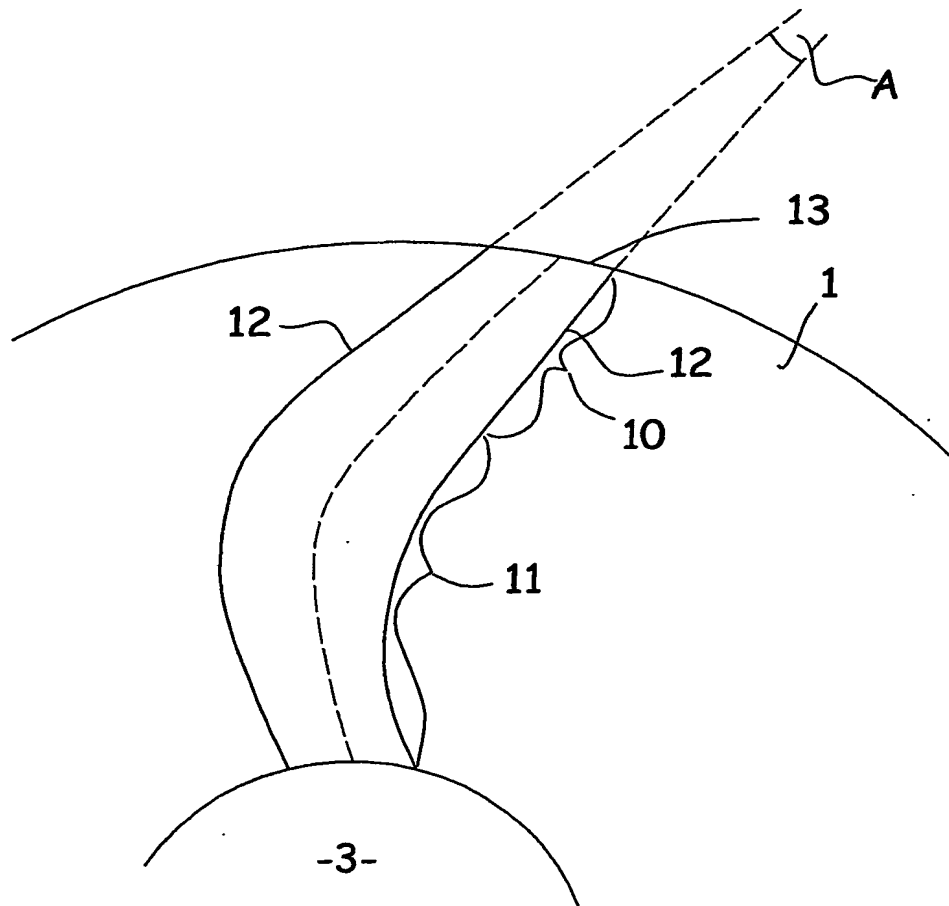


Fig 4

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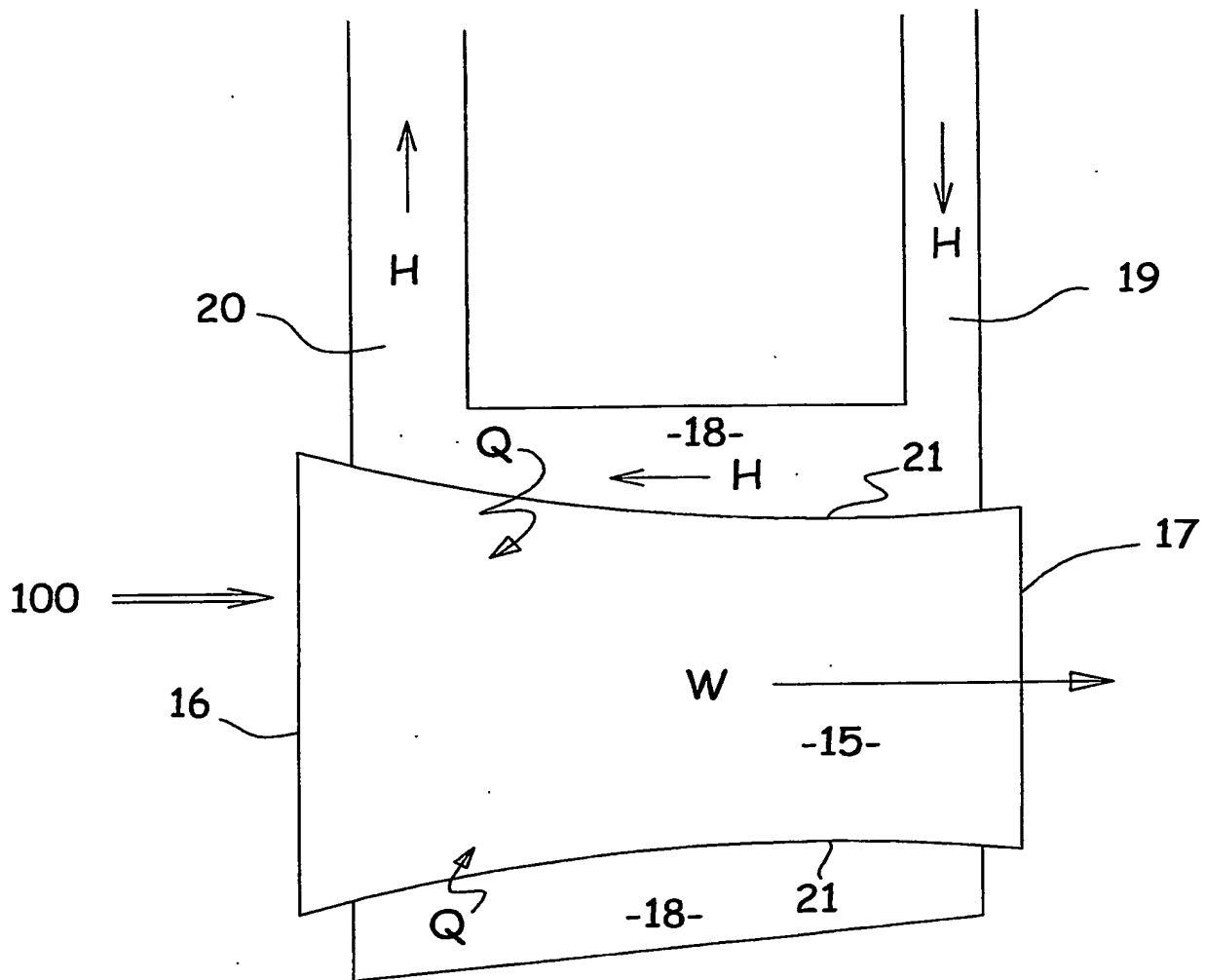


Fig 5

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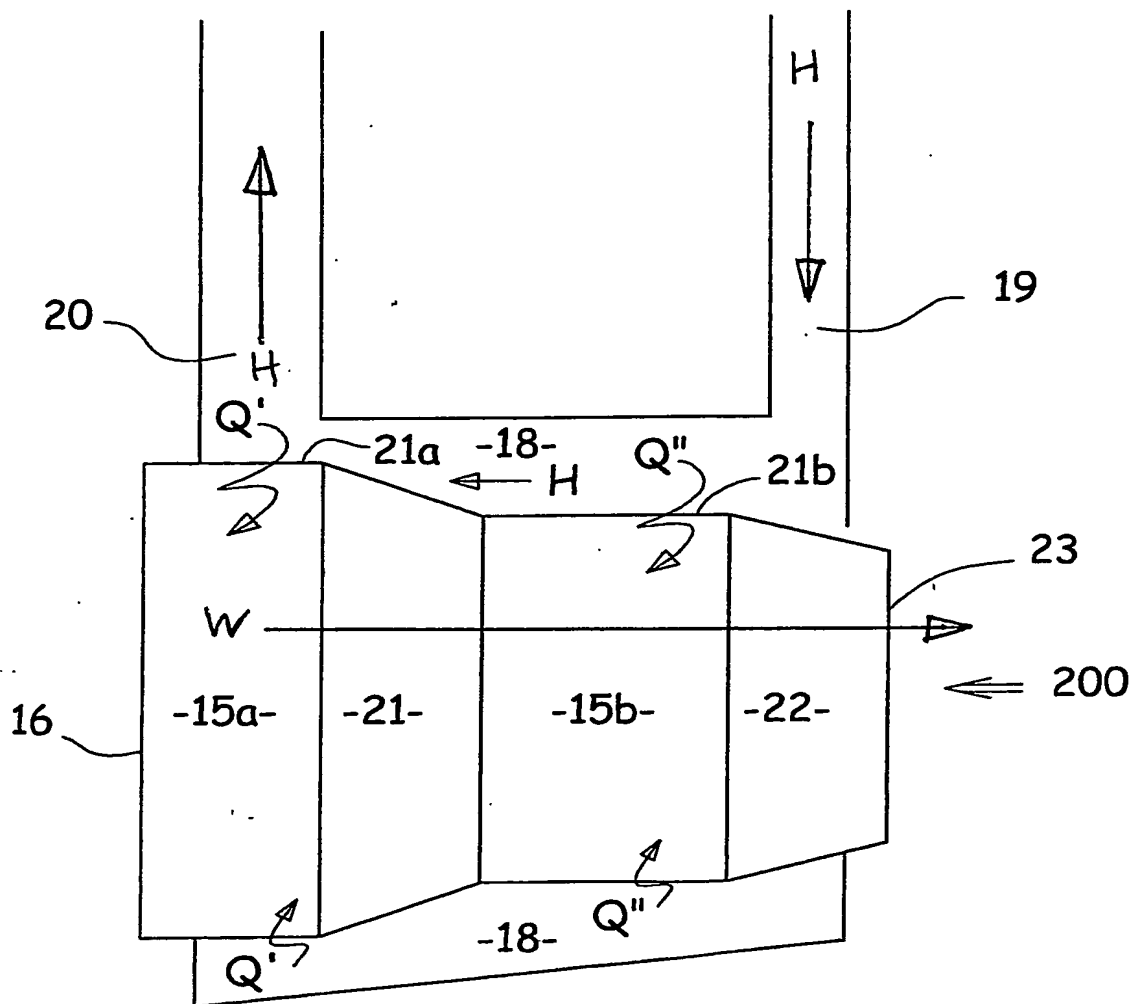


Fig 6

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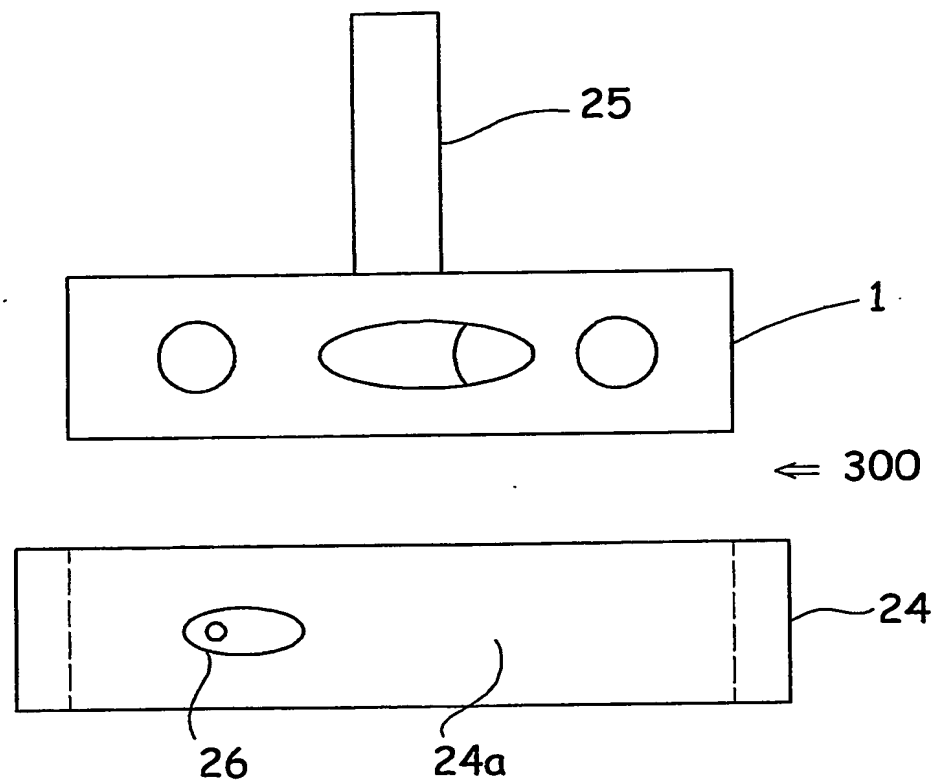


Fig 7



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